had been partly converted into water in consequence of the rising temperature. The rain water that fell with the particles of ice soon froze to smooth sheets of ice.

The hail in question gradually accumulated to a thick layer. It consisted of an extraordinary large number of small spheres, generally only a few millimeters in diameter, which, by their clear transparency, presented a very beautiful appearance. The little spheres lay at first close to each other on the ground and were rolled about by the wind. Afterwards, by partial thawing and freezing or by freezing the water between them, they adhered to each other and thus produced the impression of transparent fish roe.

The perfect clearness of the dainty drops of ice made it improbable that they would have a radial structure like the sphereolites. Under the microscope many of these, as seen by polarized light, were demonstrably composite, but a great number, on the other hand, and especially the smaller ones, seemed to be simply and uniformly constructed out of one single crystal of ice. We have, therefore, here a remarkable case of individual spherical crystals which, in opposition to the ordinary angular form of the crystal, possess an outer surface of uniform curvature, so that a description in crystalographic nomenclature could only be obtained after a physical determination of the axes. These little spheres under polarized light, viz, between crossed nicol prisms, showed very beautiful polarization phenomena; as they were not hollow, they showed in the center the higher colors, for instance, the green of the second order and diminishing outward in ring-like zones they showed the lower colors in gradual transition. The changing of these polarization colors as the ice spheres melted was especially beautiful.

The extinction of the light as the analyzing prism was turned was smooth and clean, so that, considering the positive double refraction of the ice, the meridian plane of the sphere could easily be determined. Those spheres that lay in appropriate positions upon the stage of the microscope showed in converging polarized light the phenomena characteristic of optical uniaxial crystals, and by testing with a thin plate of gypsum, corresponding with the red of the first order, showed positive double refraction.

Some of the ice particles were bounded by a circular plane surface and a portion of a spherical surface. They were, therefore, certainly only pieces of hailstones, but as it was precisely these that showed the black cross with bright rings when examined with converging polarized light as they lay upon their flat faces, it would seem as though the respective spheres in consequence of their cleavability had been cloven along one of their principal planes by striking other hard bodies; at least this explanation seems to me more probable than that of an original hemimorphic structure in the crystals.

The complex ice spheres showed in polarized light a honeycomb appearance, whence it may be inferred that they were made up of a number of nucleii; the arrangement of the nucleii was irregular. Occasionally in such a little sphere of ice there would be remarked a needle of ice whose location in reference to the sphere seemed not to be arranged according to any law. The needles or bars of ice themselves showed that they were built up of nucleii irregularly arranged. Microscopic round and irregular-shaped bubbles of air collected in groups on the surfaces were quite frequently found, notwithstanding the extreme clearness of the ice formation.

As to the question of the origin of the spherical crystals of ice and the crystalline bars it can not be doubted that we have to do with frozen drops of rain.

I have attempted to make such frozen spheres artificially. If we allow a drop of distilled water that is hanging at the end of a delicate thread, and that forms a nearly spherical ball, to freeze, we obtain a clear sphere of ice. These artificial formations all prove to be complex in their structure.

In their mode of occurrence the above-mentioned spheres of ice remind one in some respects of the chondrule of meteoric stones. (The chondrules are small spherical grains of foreign minerals often with an imperfect radial structure imbedded in meteoric stones.) The history of the origin of these forms is probably also analogous to that of the spheres of ice, in so far as they are frozen drops. The sphere of ice as a unit corresponds especially to the monosomatic chondrule of Tschermak, in which the whole of the little sphere is built up of one round crystal as a unit.

The rest of Professor Rinne's article relates to the structure of meteors rather than to that of hailstones. If we may pass from his study of this particular case of sleet and hail to the larger hailstones that accompany American thunderstorms, one might infer the probability that the latter, upon examination with polarized light, would also be found to have a composite structure. But such matters should not be left to analogy or hypothesis. It is very much to be desired that the numerous physicists of our colleges and schools of science should apply their elaborate outfits of optical apparatus to the minute investigation of the destructive but magnificent hailstones that so frequently occur in connection with our violent thunderstorms.

THE ANCIENT CLIMATE OF ARIZONA.

In May last, Mr. W. T. Blythe, Weather Bureau observer at Phœnix, Ariz., sent to the Central Office some specimens of seeds, cloth, and cord taken from a mummy found among the cliff dwellings of Arizona. In hopes that the nature of the plants to which these three objects belonged might be identified, and that something might result by way of information relative to the climate at the time these plants were living, the specimens were referred to the botanist of the Department of Agriculture. It was ascertained by microscopic examination that "the cloth was made of cotton, but the cord accompanying it was made of a fibre that is not at present recognizable. The seeds appeared to be those of an Aramantus, several species of which are still in use for food by various peoples, including the Indians of the southwestern portion of the United States." An effort was made to raise some plants from these seeds, but they failed to germinate. The general outcome of this study is simply to show that there is no evidence of any material change in the climate of Arizona since the days of the cliff dwellers.

VITALITY OF SEEDS.

Many stories are current in the newspapers of success in sprouting and raising plants from seeds found in Egyptian and Peruvian mummies or burial places, and even still more extravagant tales of plants raised from seeds buried many feet deep in the earth in strata that must have been laid to rest not only in the days of the glacial epoch but in still earlier geological ages, but not a single one of these stories has stood the test of careful investigation; either they were pure fabrications or the plants that actually grew belonged to modern flora and sprang from really fresh seeds; it is proper to say that the cautious botanist puts no faith whatever in these stories, partly because the proper tests have not been applied, but principally because of the results of so many experiments that have been made with great care to test the vitality of ordinary seeds. Every farmer knows that the proportion of seeds that will sprout diminishes year by year the longer the seeds are kept, so that at the end of ten years not one per cent of the ordinary seeds retain their vitality. There are indeed certain plants which in their wild or natural state have a vastly greater vitality than others, but the seeds of food plants cultivated by mankind are among the most delicate. The molecular structure of seeds, and not only seeds, but almost every other substance, whether animal, vegetable, or mineral, undergoes a slow change with time. Wherever sunshine, air, and water can penetrate, there molecular changes are persistently going on; these changes are usually of the nature of a slow oxidation; in the case of animal and vegetable material buried under the soil, far away from sunshine and air, there is a rearrangement of the molecules of carbon, oxygen, and hydrogen, so that they become converted into coal oil and coal oil gas. It is contrary to nature that seeds should retain their vitality under these circumstances; nevertheless the attempt to make them germinate should be made because it does seem as though there might, by chance, be found one that had escaped decomposition. It is equally important to first subject ancient seeds and fabrics, wherever found, to a microscopic examination, since some minute detail of structure may reveal the nature of the plants from which they came.

In general, those Weather Bureau observers and correspondents who happen to be in a position to collect interesting mementoes of the early races that have inhabited this continent would do well to refer their finds directly to the National

Museum at Washington rather than attempt any original investigations of their own, since the proper interpretation of archeological remains is a matter that has been found to require the greatest caution and the most extensive knowledge.

MAURITIUS—METEOROLOGY AND CROPS.

We note that the annual report for 1895 of the Royal Alfred Observatory, on the Island of Mauritius, comes to us with the signature of F. F. Claxton, assistant in charge of the Observatory, he having been appointed first assistant at the close of the year and entering on his duties on February 10, 1896. Since that date Mr. Claxton, who was formerly an assistant at Greenwich Observatory, has been appointed to the position of director, succeeding Meldrum, whose life work has made this Observatory so famous. In this annual report, for 1895, Mr. Claxton gives a table showing the mean annual rainfall for four stations on the Island as compared with the total crop of sugar for the corresponding calendar year, from 1880 to 1895, which we reproduce in the following table, except only that we have rearranged the figures in the order of the annual rainfall:

Rainfall.	Sugar crops.	Year.
Inches.	*Kilograms.*	
42.52	102,376,271	1886
54.35	119,731,492	1880
59.27	127,784,339	1884
59.86	115,299,039	1885
62.84	139,751,810	1893
66.52	117,809,610	1881
68.11	113,795,319	1894
69.40	124,078,140	1887
70.59	130,220,273	1890
72.10	135,564,900	1895
75.67	120,396,858	1883
76.13	68,718,578	1892
78.28	113,813,075	1891
91.71	124,564,951	1889
98.35	116,719,997	1882
106.23	132,172,968	1888

If we divide this series of figures into three groups of five each, omitting the year 1892, when a disastrous hurricane occurred on the 29th of April, we obtain the following averages which give us some idea as to the importance of the

Five year averages.

Rainfall.	Sugar crop.	Date.
55.76	120,968,590	1885.6
69.34	124,292,648	1889.4
90.05	121,533,574	1886.6

annual quantity of rainfall. These averages, as will be seen by the dates of the average crop year, partially eliminate any progressive change in the area devoted to the sugar crop, the style of agriculture, or any other slow change that is going on, and we may infer that the increase of annual rainfall from 55 to 90 inches has had approximately no effect in increasing the total crop. But this must not be misunderstood as implying that rainfall has nothing to do with crop production. The fact is that the sugar cane requires about eighteen months for ripening from the time of planting. A field that is planted in September will be gathered in June of the second following year. The crop then gathered must be compared with the rainfall during those eighteen months, and, more especially, during the middle portion of that interval. It is evident, therefore, that the comparison which we have been able to make, as suggested by Mr. Claxton's figures, is not a fair one, and that the subject must be pursued with more detail, very much as was done by Rawson and Walcott in their studies upon the sugar crop of Barbadoes.

A similar remark must be made with regard to the majority of the compilations of statistics that have been made by those who would elucidate the relation between climates and crops. The rainfall, temperature, humidity, sunshine, and the condition of the soil must be discussed separately for the four divisions of the plant's life. The matter is too complex to be treated by means of crude statistics without an intellectual perception of the laws of plant growth.

As the drought of 1896 in Mauritius was but one item in the destructive drought that prevailed all over the South Pacific, as well as over parts of the Northern Hemisphere, the Editor reserves his discussion of that important subject for the next REVIEW.

PRACTICAL SCIENCE IN GERMANY.

In the MONTHLY WEATHER REVIEW for April, 1895, Vol. XXIII, p. 131, we have dwelt upon the importance to the farmer, and for that matter to the whole country, of the establishment of some Government office—a bureau where the useful efficiency and relative value of machines for agricultural purposes may be thoroughly and officially determined—analogous to the Bureau of Weights and Measures and the offices for testing seeds, investigating fibres, testing the strength of woods, extirpating dangerous diseases, etc.

Somewhat analogous to these latter various bureaus that have from time to time been established in the United States, is the one central institution that has been founded in Germany under the name of the Physical-Technical Institute, which is located at Charlottenburg (formerly a suburb but now included as a part of the city of Berlin), the province of which is to carry out scientific investigations and practical tests that are beyond the reach of the ordinary laboratory, and that are of fundamental or general importance to the whole country.

The following is an abstract of a report prepared by the United States Consul-General at Frankfort, Germany, Frank H. Mason, and published in the number for July, 1897, of the Consular Reports of our State Department:

From the series of expert investigations that have been made during the past two years by English economists and commissions to ascertain the underlying causes of Germany's rapid and ominous advance as a manufacturing nation, one definite conclusion has been convincingly drawn. This is, that, putting aside all questions of protective duties, comparative wages, supply of native materials, etc., Germany, as an industrial nation, enjoys in two respects distinct advantages over Great Britain and every other European country. These are, first, the wide diffusion and high standard of technical and industrial education provided in this country; and second, the liberal and intelligent support that is given by the imperial and various state governments to the development of theoretical science and the higher and more scientific forms of industrial enterprise.

In support of the latter of these propositions, and as an illustration of how far a moderate expenditure of money, under Government authority, can be made to reach in the advancement of scientific investigation and the promotion of engineering and kindred enterprises, the Imperial Physical-Technical Institute at Charlottenburg, Berlin, is cited as the highest existing example of its class, and a model for the study and imitation of other governments which are seeking, as Germany has done since 1856, to prepare and equip their people for the industrial struggles of the future.

The introduction into Congress of a measure like the Hale engineering experiment station bill is a sign that in our own country the need of Government aid in this direction is recognized, and the following brief account of the plan and functions of the great parent institution at Charlottenburg is submitted as a contribution to a movement that has been already initiated.

The Physikalisch-Technische Reichsanstalt, to use its German official designation, was founded in 1887, mainly through the influence of the eminent electrician Werner von Siemens, who gave for the purchase of the site of the institute 500,000 marks ($119,000). The first president of the institution was the renowned physicist, Prof. Hermann L. F. von Helmholtz, who, since his death in 1895, has been succeeded by Prof. Dr. Friedrich Kohlrausch.

The institution comprises two sections, as follows: The physical department, which has for its field the advancement of pure science, or, in the language of Professor Helmholtz, "the prosecution of scientific